VARIATION IN THE REPRODUCTIVE STATUS OF SWARMS OF ANTARCTIC KRILL.

The swarming behaviour of Antarctic krill, *Euphausia superba*, is central to its biology. The biological composition of adjacent krill swarms expressed through characteristics such as mean length, sex-ratio and stages in the moult cycle of krill may be very different, e.g. Watkins 1986. In addition the size range of krill in swarms may be restricted in comparison to the local population (Marr, 1962; Hamner, 1984; Watkins, 1986). Such observations have given rise to proposals for sorting mechanisms based on differential swimming or sinking rates (Mauchline, 1980; Kils, 1981). Here we consider the maturity and size composition of animals in 38 swarms to see if a size-related sorting mechanism could account for observed distribution of maturity stages.

Results and Discussion

Swarms were sampled with a large Longhurst Hardy plankton recorder (Bone, 1986) during a 14 day period in February and March 1985 from an area approx 50 km square between Elephant Island and King George Island. The length and sexual maturity stage were measured on up to 100 krill from each swarm (Morris *et al*., 1988).

The sex composition of swarms was highly variable, male and female krill were found in all swarms but the relative proportions in the individual swarms varied greatly (proportion male 19–98%). The swarms were also either virtually all adult or contained a large proportion of subadults. In only 11 swarms was the proportion of adults less than the population average (83%), reaching a minimum of 37% in one swarm. The relative frequency of occurrence of the individual maturity stages within the swarms varied considerably. The two adult male stages were found in all swarms, but no single female maturity stage occurred in every swarm. There was also variation in the number of maturity stages in a swarm: some swarms contained every maturity stage while in others as few as two stages were present. Animals of similar maturity often occurred together as indicated by the significant correlations between all the immature maturity stages and also between the more mature adult stages.

The difference between the length of the largest and smallest krill within each swarm varied greatly (11–30 mm; median 15 mm). The size range in the swarms was significantly more restricted than would be expected if the distribution of size range was random (Kolmogorov-Smirnov test $p<0.001$). Mature krill tend to be larger than immature krill although there is some evidence of size regression after spawning. In addition, the mean size of each particular maturity stage varied between swarms. In some swarms the mean lengths of each maturity stage were longer than average while in others they were shorter than average.

Could these patterns of maturity stage arise as a result of this size-related sorting? Associated maturity stages were not necessarily of a similar size. There was no correlation ($r = 0.175$; $P>0.1$) between the size difference of each maturity stage and the degree of association between maturity stages. Thus, for example, subadult male krill (MS1, MS2 and MS3) were usually found together but the mean sizes of these stages ranged from 42.8–48.4 mm. In contrast, subadult male krill (MS3) and adult male krill (MA2) were negatively associated but the difference between the mean size of these stages was 0.1 mm. It also seems unlikely that differences in sex ratio of the swarms could be explained simply by size differences in the maturity stages because the size differences between the equivalent male and female maturity stages (e.g. MA2 and FA4) were usually small, although sometimes statistically significant.

Passive sorting mechanisms based on size-dependent swimming or sinking speeds and differential growth may explain the inter-swarm differences in krill size, however, they appear to account for little of the inter-swarm variation in sex and maturity stage. The very low numbers of maturing females found without attached spermatophores suggests that mating must occur rapidly after each moult. Because of the very uneven numbers of males and females in many swarms it is likely therefore that active behavioural responses are important in bringing male and female krill together to mate. Thus the swarms containing only mature males may be actively searching for aggregations of mature female krill. However, the actual mechanisms for producing the observed swarm distributions of reproductively active and inactive maturity stages have still to be determined.

Literature Cited

Bone, D.G. 1986. An LHPR system for adult Antarctic krill (*Euphausia superba*). British Antarctic Survey Bulletin 73: 31–47.

Hamner, W.M. 1984. Aspects of schooling of *Euphausia superba*. Journal of Crustacean Biology 4: 67–74.

Kils, U. 1981. Size dissociation in krill swarms. Kieler Meeresforschung Sonderhaft 5: 262–263.

Marr, J.W.S. 1962. The natural history and geography of the Antarctic krill (*Euphausia superba* Dana). Discovery Report 32: 33–464.

Mauchline, J. 1980. The biology of mysids and euphausiids. Advances in Marine Biology 18: 1–681.

Morris, D.J., Watkins, J.L., Ricketts, C., Buchholz, F. and Priddle, J. 1988. An assessment of the merits of length and weight measurements of Antarctic krill *Euphausia superba*. British Antarctic Survey Bulletin 79: 27–50.

Watkins, J.L. 1986. Variations in the size of Antarctic krill, *Euphausia superba* Dana, in small swarms. Marine Ecology Progress Series 31: 67–73.

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